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Optimization of the Processing Conditions for the Preparation of Surimi Products Containing Rice Flour

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Abstract

Surimi (or fish paste) products are one of the most representative processed seafoods in Korea. In a previous study, we evaluated the potential use of rice flour as an agent to replace wheat flour in surimi products. In this study, we optimized the content of rice flour and water in surimi products using response surface methodology. Rice flour content (X_1, w/w) and water content (X_2, v/w) were chosen as independent variables and gel strength (Y_1) and overall acceptance (Y_2) as dependent variables. Optimal conditions of X_1 and X_2 were 14% and 9.1%, respectively, and the predicted values of the multiple response optimal conditions were Y_1 = 656.4 (g·cm) and Y_2 = 6.34. Under optimal conditions, the experimental values of Y_1 and Y_2 were 647.8 (g·cm) and 6.21, respectively, which were similar to the predicted values. Surimi products that are prepared under optimum conditions were similar in gel strength to those of commercial products. However, its sensory evaluation score was higher than that of the commercial products. In conclusion, rice flour can not only be used as an alternative to wheat flour, but it also can be used to improve the quality of surimi products.

Key words: Rice flour, Surimi product, Response surface methodology, Gel strength, Sensory evaluation

Introduction

Surimi (or fish paste) products are the most representative processed fishery foods. They are widely used because their cooking is simple and inexpensive. In addition, surimi products can easily change the shape, taste, and texture of the final product as per consumer preferences (Kim et al., 2005). In South Korea, the most popular surimi product is the fried type, which is traditionally mixed with vegetables (Park, 2005a; Choi et al., 2012). Currently, most surimi products are prepared using starch or wheat flour as an ingredient. Unfortunately, the price of wheat flour has increased and consumers were required high-quality products. Therefore, there is a need to come up with a cheaper alternative to replace wheat flour. Recently, rice flour was highlighted as a possible alternative to wheat flour (We et al., 2011).

Rice is the major staple crop of nearly half of the world's population, and is particularly important in Asia, where approximately 90% of the world's rice is produced and consumed (Zeigler and Barclay, 2008; Khush, 2004; Lee, 2012). However, rice consumption in South Korea has decreased sharply owing to westernization of diet and increasing popularity of instant foods (Cha, 2010; Statistics Korea, 2011). Most rice are consumed after simple cooking and therefore the South Korean food industry is exploring the use of rice in new foods, both for domestic consumption and for export purposes (Shin, 2009). The rheological properties and manufacturing process of surimi products containing different starches or functional powders, such as potato (Yang and Park, 1998; Tabilo-Munizaga and Barbosa-Canovas, 2005; Chung and

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Lee, 1996), waxy corn (Alvarez et al., 1997), wheat (Kong et al., 1999), red ginseng (Shim et al., 2012), *Lycii fructus* (Shin et al., 2008), and *Poria cocos* (Shin et al., 2009) have been reported. Currently, there exists few papers on the use of rice flour as a gel-enhancing ingredient in surimi products studied (Jung and Yoo, 2005; Jung et al., 2007; Hur et al., 2011). However, the relationship between rice flour and surimi with regard to rheological properties and sensory evaluation has not been fully elucidated. In particular, no attempt has been made to optimize the content of rice flour in surimi products. In a previous study, we evaluated the effect of rice flour addition on the rheological and sensory properties of surimi products to check for the feasibility of using rice flour as an alternative to wheat flour for the production of premium surimi products (Cho et al., 2013). Therefore, the objective of the present study was to determine the optimum formulation of surimi products containing rice flour by using response surface methodology.

Materials and Methods

Materials

Golden threadfin bream (*Nemipterus virgatus*) surimi (grade A; Khan Hoang Seaprex Co., Ltd., Soc Trang, Vietnam) was used in this study. (This surimi contained the usual cryoprotectants (e.g., sucrose, sorbitol, sodium polyphosphate, and sodium pyrophosphate)). Randomly selected surimi blocks (10 kg) were cut into 1 kg portions and kept at -20°C until further use. Rice flour (roll-mill, 80 mesh) was purchased from Daesun Flour Mills Co., Ltd. (Hampyeong, Korea). The other ingredients (Table 1) were provided from Hansung Enterprise Co., Ltd. (Seongnam, Korea).

Preparation of the surimi product containing rice flour

Frozen surimi was partially thawed for 1 h at room temperature, to allow the core temperature to reach approximately -5°C. The thawed surimi was then cut into cubes (5 × 5 × 5 cm) and placed in a chopping bowl. The sample was chopped further at 1500 rpm for 5 min by a silent cutter (OMF-500, Ohmichi Co., Ltd., Maebashi, Japan). Two percent salt was added and the sample chopped for another 5 min at 1500 rpm. Rice flour was added slowly until homogenization of the mixture. The other ingredients were then added to the homogenized mixture according to the amounts listed in Table 1 and mixed for 3 min by the silent cutter. The formulation of Table 1 was selected because it is a general combination of ingredient for the production of commercial surimi products. During the chopping and mixing procedure, the temperature was maintained at approximately 5°C by crushed ice bath. After molding of the mixture, it was fried in soybean oil for 3 min at 150°C. All samples were then vacuum-packed and stored at 4°C.

Table 1. Ingredients (g) of the preparation of surimi products containing rice flour

Frozen surimi	Soy protein	Sugar	Salt	Egg white	Xylose
100.0	1.5	2.3	2.0	6.7	0.3

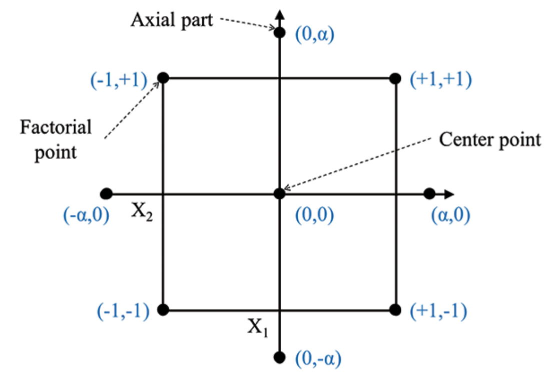


Fig. 1. The example points of a central composite design (CCD) with two input parameters.

Determination of gel strength

Breaking force and deformation of the surimi product was measured by a puncture test using a TA-XT2 texture analyzer (Stable Micro Systems, Surrey, UK) equipped with a 0.25-inch spherical stainless probe. When the gel sample lost its strength and ruptured at a crosshead speed of 1.0 mm/s, the breaking force and depth of depression were recorded. Ten cylindrical samples with a length of 2.5 cm were subjected to the test. Gel strength was calculated using the following formula:

Gel strength (g·cm) = breaking force (g) × depth of depression (cm).

Sensory evaluation

A trained panel comprising 20 members of the Korea Food Research Institute determined the organoleptic characteristics of the sample. The outward appearance, color, flavor, taste, chewiness, hardness, and overall acceptance were evaluated by a 7-point Likert scale (1 = extremely dissatisfied, 7 = extremely satisfied).

Experimental design

Central composite design (CCD) (Box and Wilson, 1951) was adopted in the optimization of rice flour and water content proportions in surimi products (Fig. 1). CCD matrix consists of 2^2 factorial points, 4 axial points (α = 1.414) and 3 center points. Rice flour content (X_1, %) and water content (X_2, %)

were chosen as the independent variables (IVs). The range and center point values of the two IVs were based on the results of preliminary experiments (Table 2). Commonly, the minimum content of wheat flour was 5% in the commercial surimi products. In addition, when the rice flour added more than 15%, the prototype surimi products was not forming gel. Therefore, we chose the range of rice flour content from 5% to 15%. Gel strength (Y_1, g·cm) and overall acceptance (Y_2) were selected as the dependent variables (DVs) for the different combinations of IVs (Table 3). To minimize the effects of unexpected variability in the observed responses, the experimental runs were randomized.

Analysis of data and optimization

For the response surface regression procedure, MINITAB software version 14 (Minitab Inc., Harrisburg, PA, USA) was used to fit the following quadratic polynomial equation:

$$Y = \beta_0 + \sum_{i=1}^{p} \beta iXi + \sum_{i=1}^{p} \beta iiXi^2 + \sum_{i<j=2}^{p} \beta ijXiXj$$

where Y is the dependent variable (gel strength and overall acceptance), β_0 is a constant, βi, βii and βij are regression coefficients and Xi, Xj are the levels of the independent variables. The DVs, Y_1 (gel strength) and Y_2 (overall acceptance), were considered as parameters for optimization in order to prepare a sample with the highest gel strength and overall acceptance. The response surface plots were developed using Maple software version 7 (Waterloo Maple Inc., Ontario, Canada) and represented a function of two IVs.

Table 2. Experimental range and values of the independent variables in the central composite design for preparation of surimi products containing rice flour

Independent variables	Symbol	Range and levels				
		-1.414	-1	0	1	+1.414
Rice flour content (%, w/w)	X_1	5	6.5	10	13.5	15
Water content (%, v/w)	X_2	7	8	10.5	13	14

Statistical analysis

Statistical analyses of data were performed using SPSS software Version 13 (SPSS Inc., Chicago, IL, USA). Results were presented as average and standard deviations. Tukey's multiple range test was carried out with one-way analysis of variance (ANOVA) to determine the significance of the differences in the mean among treatments. The significance level was set at $P < 0.05$ for all analyses.

Results and Discussion

Diagnostic checking of the fitted models

Response surface methodology (RSM) is a useful statistical technique that has been applied to optimize formulations in various food products (Murphy et al., 2004). This methodology reduces the number of experimental runs required to generate sufficient information in order to provide a statistically acceptable result (Fogaça et al., 2013). The response surface regression procedure was employed to fit the quadratic polynomial equation to the experimental data. All the coefficients of linear (X_1, X_2), quadratic (X_1X_1, X_2X_2) and interaction (X_1X_2) were calculated for its significance using the *t*-test, and the estimated coefficients of each model are presented in Table 4. In all models, the constant coefficients and linear terms

Table 3. Central composite design and responses of the dependent variables for preparation of the surimi products containing rice flour

Run No.		Independent variables				Responses	
		Coded		Uncoded		Y_1	Y_2
		X_1	X_2	X_1	X_2		
Factorial portion	1	-1	-1	6.5	8.0	559	5.5
	2	+1	-1	13.5	8.0	642	6.4
	3	-1	+1	6.5	13.0	395	3.9
	4	+1	+1	13.5	13.0	582	5.6
Star portion	5	-1.414	0	5.0	10.5	513	4.8
	6	+1.414	0	15.0	10.5	630	6.0
	7	0	-1.414	10.0	7.0	657	6.3
	8	0	+1.414	10.0	14.0	390	4.0
Center portion	9	0	0	10.0	10.5	590	5.6
	10	0	0	10.0	10.5	611	5.7
	11	0	0	10.0	10.5	607	5.9

X_1, rice flour content (%, w/w); X_2, water content (%, v/w); Y_1, gel strength (g·cm); Y_2, overall acceptance.

were highly significant ($P < 0.01$). In contrast, the X_1X_1 term of quadratic coefficients and interaction coefficients of Y_1 (gel strength) and Y_2 (overall acceptance) were not significant. However, the X_2X_2 term of Y_1 (gel strength) and Y_2 (overall acceptance) were significant ($P < 0.05$). To develop the fitted response surface model equations, all insignificant terms ($P > 0.05$) were estimated and the corresponding fitted models are shown in Table 5. Values of the determination coefficient (R^2) for Y_1 and Y_2 were 0.946 and 0.965, respectively, and significant at the 99% probability level. The R^2 values indicate that the model equations described the experimental designs adequately (Cho et al., 2005). This result confirmed that the experimental design based on the preliminary test was adequately performed.

Table 4. Estimated coefficients of the fitted quadratic polynomial equation for responses based on *t*-statistic for preparation of surimi products containing rice flour

Parameter	Y_1		Y_2	
	Coefficient	*P*-value	Coefficient	*P*-value
Constant	602.67	0.001	5.7333	0.001
X_1	54.43	0.004	0.5371	0.001
X_2	-75.20	0.001	-0.7066	0.001
X_1X_1	-16.33	0.256	-0.1479	0.177
X_2X_2	-40.33	0.025	-0.2729	0.034
X_1X_2	26.00	0.146	0.2000	0.134

X_1, rice flour content (%, w/w); X_2, water content (%, v/w); Y_1, gel strength (g·cm); Y_2, overall acceptance.

Table 5. Response surface model for preparation of surimi products containing rice flour

Quadratic polynomial model equations	R^2	*P*-value
$Y_1 = 602.67 + 54.43X_1 - 75.20X_2 - 16.33X_1^2 - 40.33X_2^2 + 26.00X_1X_2$	0.946	0.003
$Y_2 = 5.7333 + 0.5371X_1 - 0.7066X_2 - 0.1479X_1^2 - 0.2729X_2^2 + 0.2000X_1X_2$	0.965	0.001

X_1, rice flour content (%, w/w); X_2, water content (%, v/w); Y_1, gel strength (g·cm); Y_2, overall acceptance.

Analysis of variance (ANOVA)

The statistical significance of the quadratic polynomial model equation was evaluated by analysis of variance (ANOVA). Table 6 shows ANOVA results for the models that explain the response of the two dependent variables, Y_1 (gel strength) and Y_2 (overall acceptance). The linear terms (X_1, X_2) for all the DVs were significant ($P = 0.001$ and $P = 0.000$, respectively) at the 99% probability level, whereas cross-product terms for all the DVs were not significant ($P = 0.146$ and $P = 0.134$, respectively) at the 95% probability level. The quadratic terms (X_1X_1, X_2X_2) of all the DVs were not significant ($P = 0.062$ and $P = 0.077$, respectively) at the 95% probability level. In the total regression model, all the DVs were significant ($P < 0.01$) at the 99% probability level. If the lack-of-fit test is not significant, then the model is fit (Isa et al., 2011). The results of the lack-of-fit test show that the F values of Y_1 and Y_2 were 11.62 and 2.91, respectively, and the related *P*-values were not significant (0.080, and 0.266, respectively) at the 95% probability level. These results indicate the suitability of the models to accurately predict variation.

Table 6. Analysis of variance (ANOVA) for response of dependent variables (Y_1 and Y_2)

Response	Source		DF	SS	MS	*F*-value	*P*-value
Y_1	Regression	Linear	2	68943.1	34471.5	37.62	0.001
		Quadratic	2	9310.1	4655.0	5.08	0.062
		Cross-product	1	2704.0	2704.0	2.95	0.146
		Total model	5	80957.1	16191.4	17.67	0.003
	Residual	Lack of fit	3	4332.9	1444.3	11.62	0.080
		Pure error	2	248.7	124.3		
		Total error	5	4581.6	916.3		
	Total		10	85538.7			
Y_2	Regression	Linear	2	6.30220	3.15110	62.84	0.000
		Quadratic	2	0.44890	0.22445	4.48	0.077
		Cross-product	1	0.16000	0.16000	3.19	0.134
		Total model	5	6.91110	1.38222	27.57	0.001
	Residual	Lack of fit	3	0.20405	0.06802	2.91	0.266
		Pure error	2	0.04667	0.02333		
		Total error	5	0.25072	0.05014		
	Total		10	7.16182			

DF, degrees of freedom; SS, sum of square; MS, mean square.
X_1, rice flour content (%, w/w); X_2, water content (%, v/w); Y_1, gel strength (g·cm); Y_2, overall acceptance.

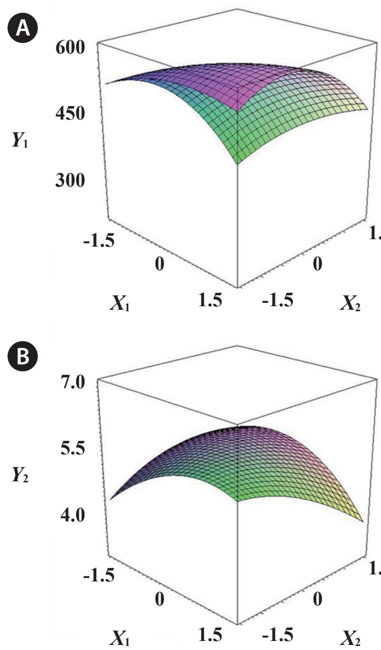


Fig. 2. 3D plot for preparation of surimi products containing rice flour for gel strength (A) and overall acceptance (B). X_1, rice flour content (%, w/w); X_2, water content (%, v/w); Y_1, gel strength (g·cm); Y_2, overall acceptance.

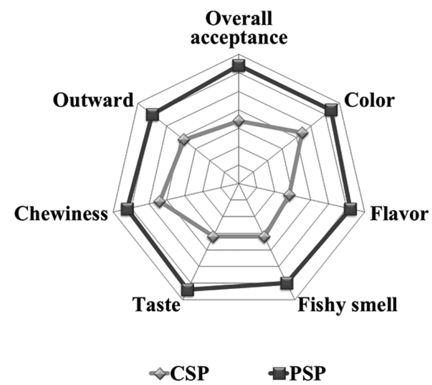


Fig. 3. Sensory evaluation of the prototype surimi products (PSP) and the commercial surimi product (CSP).

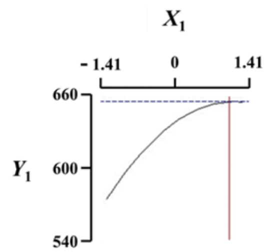
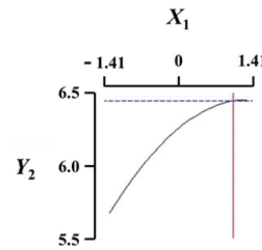
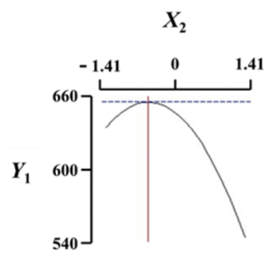
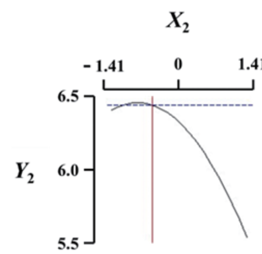
Response surface plots and the effect of factors

The estimated response function and the effect of the IVs on the DVs are shown in Fig. 2. When X_1 increased from 5 % (-1.414) to 15 % (+1.414), Y_1 and Y_2 increased. However, when X_2 increased from 7 % (-1.414) to 14 % (+1.414), Y_1 and Y_2 were decreased. In a study by Chen et al. (1993), starch addition up to 8% increased gel strength while lowering the expressible moisture value. This result is similar to our result where we show that the gel strength and moisture values have an inverse relationship. In addition, in a previous study, we suggested that an effective amount of rice flour to add was 10-15% (Cho et al., 2013). This result supported that rice flour content up to 15% increased gel strength and overall acceptance. As the coded values of IVs X_1 and X_2 were reached 13.5% (+1) and 9.25% (-0.5), respectively, Y_1 (gel strength) and Y_2 (overall acceptance) were increased. Generally, 4-12% of starch or wheat flour is added to surimi product (Park, 2005b). However, up to 20-26% has been used for reducing the cost of surimi products (Hunt et al., 2009; Shim et al., 2012). Therefore, we suggest that rice flour can be more useful than wheat flour for reducing the costs of premium surimi products.

Optimization of multiple responses and comparison of quality characteristics with commercial products

Optimal conditions included both coded and uncoded values of the dependent variables (Y_1, and Y_2), which are shown in Table 7. According to the canonical analysis of the response surface regression procedure, the eigenvalues of Y_1 was positive and the eigenvalue of Y_2 was negative. Therefore, the stationary points were target values. To obtain the optimal proportion of rice and water in surimi products, each target value, Y_1 (gel strength) and Y_2 (overall acceptance), were considered as a parameter during the optimization. The multiple optimal conditions (coded and actual values) of X_1 (rice flour content) and X_2 (water content) were 1.15 (14 %) and -0.55 (9.1 %), respectively. It has been reported that starch increases the gel strength of surimi products at lower concentration of 3% instead of higher concentrations of 6-10% (Yoon et al., 1997). In contrast, our results with rice flour show the opposite trend. It is considered that the gel strength was dependent on the inherent properties of starch and other ingredients used in the surimi product formulation (Hunt et al., 2009). The predicted values of Y_1 (gel strength), Y_2 (overall acceptance) at optimal conditions were 656.4 g·cm and 6.34, respectively, and under optimal conditions, the experimental values were similar to the predicted values of Y_1 and Y_2 (647.8 g·cm and 6.21, respectively). Therefore, the estimated response surface model was adapted for optimization of rice flour content in surimi products. Surimi products produced under optimum conditions were similar in strength to the gel strength of commercial products. However, its sensory evaluation score was higher than that of commercial products (Fig. 3). In particular, typical fishy smell, which is a major cause of evasion of surimi product (Lee and Lee, 2002), was reduced by adding rice flour. Therefore, rice flour enhances the quality of surimi products and is considered a valuable ingredient in the preparation of premium surimi products.

Table 7. Multiple response optimization for the preparation of surimi products containing rice flour of predicted and experimental values

Response				Y_1	Y_2
Optimal conditions	X_1	Target value	> 650		
		Coded value	1.15		
		Actual value	14.0 (%)		
	X_2	Target value	> 6.0		
		Coded value	-0.55		
		Actual value	9.1 (%)		
Predicted value				656.4	6.34
Experimental value				647.8 ± 13.4[a]	6.21 ± 0.66[a]
Commercial product				617.8 ± 20.7[a]	3.40 ± 0.55[b]

Superscript a and b represent significant differences (P < 0.05).
X_1, rice flour content (%, w/w); X_2, water content (%, v/w); Y_1, gel strength (g·cm); Y_2, overall acceptance.

Acknowledgments

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References

Alvarez C, Couso I, Solas M and Tejada M. 1997. Waxy corn starch affecting texture and ultrastructure of sardine surimi gels. Eur Food Res Technol 204, 121-128.

Box GEP and Wilson KB. 1951. On the experimental attainment of optimum conditions. J R Stat Soc Ser B 13, 1-45.

Cha HM. 2010. A study on the trend analysis regarding the rice consumption of Korean. M.S. Thesis, Woosong University, Daejeon, KR.

Chen JS, Lee CM and Crapo C. 1993. Linear programming and response surface methodology to optimize surimi gel texture. J Food Sci 58, 535-536.

Cho S, Yoon M and Kim SB. 2013. Effects of rice flour milling types and addition methods of rheological and sensory properties of surimi products. Kor J Fish Aquat Sci 46, 139-146.

Cho SM, Gu YS and Kim SB. 2005. Extracting optimization and physical properties of yellow fin tuna (*Thunnus albacares*) skin gelatin compared to mammalian gelatins. Food Hydrocol 19, 221-229.

Choi SY, Choi EY, Lee KE, Song AS, Park SH and Lee SC. 2012. Preparation and quality analysis of fish paste containing *Styela clava* tunic. J Kor Soc Food Sci Nutr 41, 1591-1595.

Chung KH and Lee CM. 1996. Evaluation of wheat gluten and modified starches for their texture-modifying and freeze-thaw stabilizing effects on surimi based-products. J Food Sci Nutr 1, 190-195.

Fogaça FHS, Trinca LA, Bombo ÁJ and Sant'Ana LS. 2013. Optimization of the surimi production from mechanically recovered fish meat (MRFM) using response surface methodology. J Food Qual 36, 209-216.

Hunt A, Getty KJK and Park JW. 2009. Roles of starch in surimi seafood: a review. Food Rev Int 25, 299-312.

Hur SI, Cho S, Kum JS, Park JW and Kim DS. 2011. Rice flour-A functional ingredient for premium crabstick. Food Sci Biotechnol 20, 1639-1647.

Isa KM, Daud S, Hamidin N, Ismail K, Saad SA and Kasim FH. 2011. Thermogravimetric analysis and the optimisation of bio-oil yield from fixed-bed pyrolysis of rice husk using response surface methodology (RSM). Ind Crops Prod 33, 481-487.

Jung YH and Yoo B. 2005. Thermal gelation characteristics of composite surimi sol as affected by rice starch. Food Sci Biotechnol 14, 871-874.

Jung YH, Kim WW and Yoo B. 2007. Effect of acetylated rice starch on rheological properties of surimi sol and gel. Food Sci Biotechnol 16, 817-821.

Khush GS. 2004. Harnessing science and technology for sustainable rice-based production systems. Int Rice Comm News Lett 53, 17-23.

Kim HS, Choi SG, Park CH, Han BW, Yang SK, Kang KT, Oh HS, Heu MS and Kim JS. 2005. Preperation and characteristics of surimi gel with red-tanner crab (*Chionoecetes japonicus*) paste. J Kor Soc Food Sci Nutr 34, 1103-1108.

Kong DS, Ogawa H and Iso N. 1999. Compression properties of fish-meat gel as affected by gelatinization of added starch. J Food Sci 64, 283- 286.

Lee K and Lee Y. 2002. Attitude and behavior of seafood consumption among Korean housewives. Kor J Food Culture 17, 111-119.

Lee NY. 2012. Starch and pasting characteristics of various rice flour collected from markets. Kor J Food Preserv 19, 257-262.

Murphy SC, Gilroy D, Kerry JF, Buckley DJ and Kerry JP. 2004. Evaluation of surimi, fat and water content in a low/no added pork sausage formulation using response surface methodology. Meat Sci 66, 689-701.

Park JW. 2005a. Surimi seafood: products, market, and manufacturing. In: Surimi and Surimi Seafood. Park JW, ed. CRC Press, Boca Raton, FL, US, pp. 375-434.

Park JW. 2005b. Ingredient technology for surimi and surimi seafood. In: Surimi and Surimi Seafood. Park JW, ed. CRC Press, Boca Raton, FL, US, pp. 649-707.

Shim DW, Jiang J, Kim JH, Kim WW, Kang WS, Choi WS, Hur SJ, Kim DY, Kim KC and Lee KH. 2012. Effects of size adjusted with red ginseng powders on quality of fish pastes. J Kor Soc Food Sci Nutr 41, 1448-1453.

Shin M. 2009. Rice-processed food. Food Science and Industry 42, 2-18.

Shin YJ, Kim KS and Park GS. 2009. Texture and sensory characteristics of fish paste containing white *Poria cocos* wolf power. Kor J Food Cookery Sci 25, 119-125.

Shin YJ, Lee JA and Park GS. 2008. Quality characteristics of fish pastes containing *Lycii fructus* powder. J East Asian Soc Dietary Life 18, 22-28.

Statistics Korea. 2011. Household food grain consumption per capita in 2010 [Internet]. Statistics Korea, Deajeon, KR, Accessed 25 Jul 2013, http://kostat.go.kr/portal/english/news/1/8/index.board?bmode=read&aSeq=245363.

Tabilo-Munizaga G and Barbosa-Canovas GV. 2005. Pressurized and heat treated surimi gels as affected by potato starch and egg white: microstructure and water-holding capacity. LWT-Food Sci Technol 38, 47-57.

We GJ, Lee I, Kang TY, Min JH, Kang WS and Ko S. 2011. Physicochemical properties of extruded rice flours and a wheat flour substitute for cookie application. Food Eng Prog 15, 404-412.

Yang H and Park JW. 1998. Effects of starch properties and thermal-processing conditions on surimi-starch gels. LWT-Food Sci Technol 31, 344-353.

Yoon WB, Park JW and Kim BY. 1997. Linear programming in blending various components of surimi seafood. J Food Sci 62, 561-564.

Zeigler RS and Barclay A. 2008. The relevance of rice. Rice 1, 3-10.